NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

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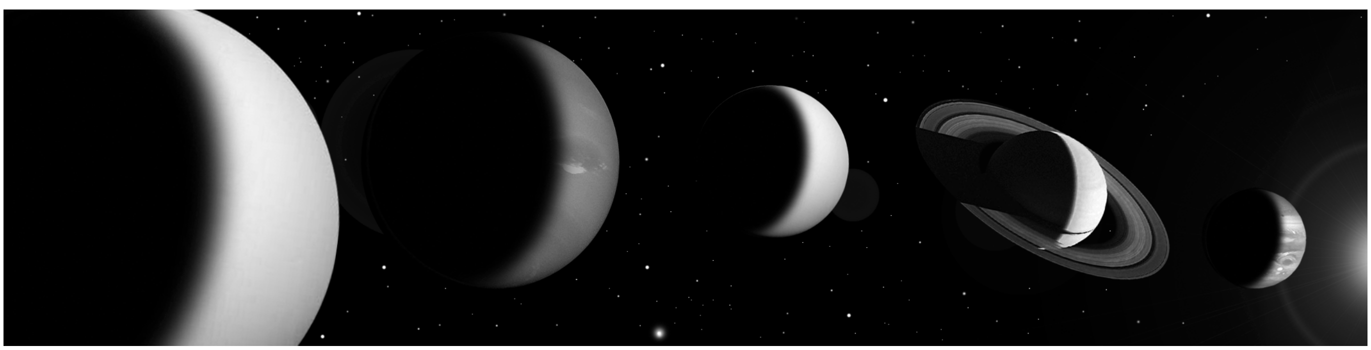
Infinite Journeys

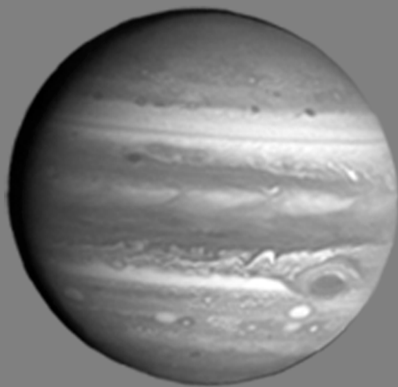
In-Space Propulsion Technologies Opening the Frontiers of Space



Imagine driving all the way from an East Coast city to the Grand Canyon in Arizona—one of the most breath-taking natural spectacles in the world. Then imagine simply driving by without slowing down, snapping as many photos as possible as it blurs past.

That's a rough equivalent of the way past missions to the outer planets—Jupiter, Saturn, Uranus, Neptune and Pluto—have been conducted. Typically, fuel loads make up half the weight of any interplanetary spacecraft. Conventional chemical propulsion systems send these probes millions of miles across the solar system, trying to get as close as they can to a planet in order to capture as much information as possible. But the lack of fuel available for orbital braking and maneuvering means the probes must fly right by each planet—or remain stuck in a limited orbit until they fall to destruction.

While humankind has learned a great deal from past visits to the outer planets—Pioneer 10 and 11 and the "grand tours" of Voyager 1 and 2—those trips have merely tantalized us with the promise of more knowl-edge and greater possibilities yet to be revealed.



Jupiter

Distance from Earth
390.6 million miles
(628.7 million kilometers)

Temperature
Interior temps may reach 35,000 degrees Fahrenheit
(19,400 degrees Celsius)

Atmosphere
90 percent normal and liquid metallic hydrogen, 10 percent helium, with traces of methane, water and ammonia

Geology
Gaseous materials densify to an inner core 10-15 times the size of Earth

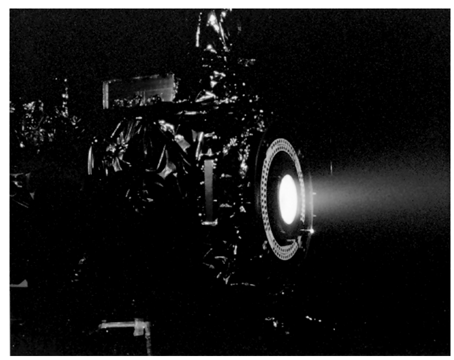
Moons
16 confirmed, 12 unconfirmed

Rings
A single, faint ring similar to Saturn's in composition

NASA is now seeking new means of enabling faster, cheaper and more cost efficient missions to the outer planets—ones that will permit more detailed, long-term studies of the outer planets, their myriad moons and other bodies in the solar system.

At the forefront of this effort is research now being conducted by the In-Space Propulsion investment area of NASA's Advanced Space Transportation Program. Part of the Space Transportation Directorate at NASA's Marshall Space Flight Center in Huntsville, Ala., the In-Space Propulsion team leads a joint effort that includes NASA scientists and technologists at Glenn Research Center in Cleveland, Ohio; Langley Research Center in Hampton, Va.; the Jet Propulsion Laboratory in Pasadena, Calif.; and other NASA field centers, as well as government, industry and academic partners around the nation.

Electric Propulsion



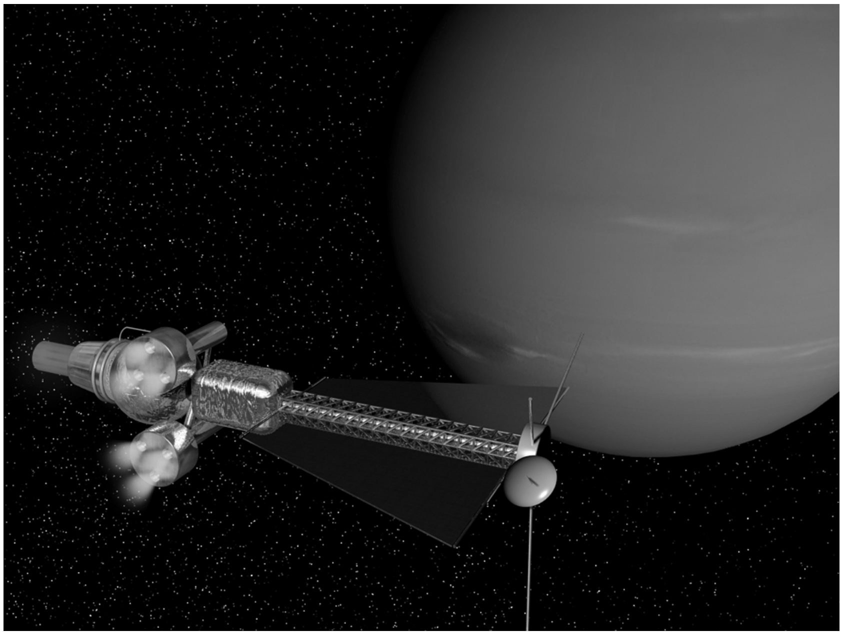
Test firing the Deep Space 1 ion propulsion engine

Electric propulsion technologies use electrical energy derived from solar or nuclear sources to accelerate a propellant, which is then converted to kinetic energy, or thrust. This lightweight alternative to heavy chemical propellant enables electric-propulsion vehicles to travel faster, carry larger payloads and accomplish broader mission objectives, unhampered by the weight and expense of current fuel requirements.

One promising electric propulsion technology is ion propulsion, which boasts 10 times the fuel efficiency of an on-board chemical propulsion system.

An ion engine currently powers Deep Space 1, NASA's successful mission to validate flight technologies and hardware for future deep-space vehicles and missions. Launched in 1998, Deep Space 1 has given NASA researchers new insight regarding in-space propulsion requirements—and made scientific history in September 2001 during its flyby exploration of comet Borrelly.

In the future, NASA expects higher-performance ion engines to become leading candidates for propelling missions to Europa and other Jovian moons, and to the other outer planets—even distant Pluto. Research into lightweight ion propulsion system components and subsystems is now underway.



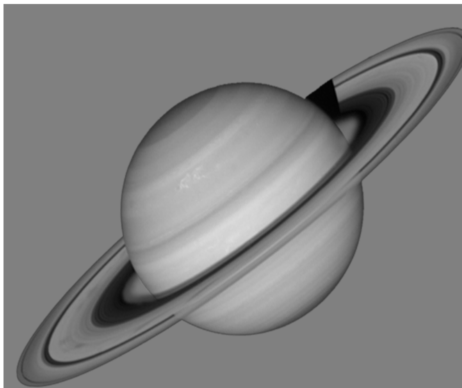
An artist's rendering of a fission-propelled spacecraft en route to Neptune

Fission Propulsion

NASA is developing advanced propulsion technologies based on fission, or the release of energy by splitting atomic nuclei—paving the way for rapid transit to any point in the solar system. Fission propulsion is being positioned to enable automated science missions to the outer planets and their moons in years to come, and eventually could lead to crewed voyages from Earth to Jupiter in under a year.

The fission process—which is essentially non-radioactive throughout pre-launch activities and launch itself—would initiate in space with the splitting of uranium fuel into two or more elements, resulting in liberation of tremendous amounts of energy. Research now under way at NASA will allow engineers to design and test an entire fission system without actually initiating fission. The Safe Affordable Fission Engine, or SAFE project, uses electrical resistance heaters in place of uranium fuel to simulate the heat released from fission.

Flight demonstrations of fission-based propulsion systems could occur as early as 2011, and be in use for outer-planet missions by 2015.



Saturn

Distance from Earth
795.2 million miles
(1.27 billion kilometers)

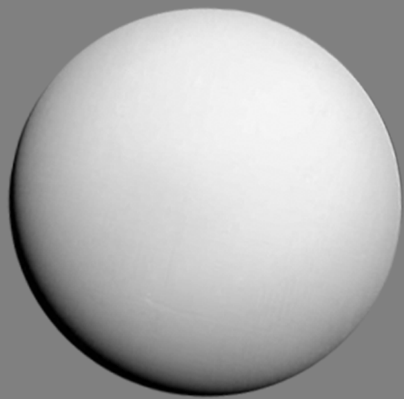
Temperature
Interior temps reach 21,000 degrees Fahrenheit (11,600 degrees Celsius)

Atmosphere
Approximately 75 percent hydrogen and 25 percent helium, with traces of water, methane and ammonia

Geology
Gaseous surface above liquid-metallic hydrogen layers, molecular hydrogen layers and a rocky core

Moons
18 confirmed, 12 unconfirmed

Rings
Trademark rings are composed of water ice and icy rock particles



Uranus

Distance from Earth
1.69 billion miles
(2.72 billion kilometers)

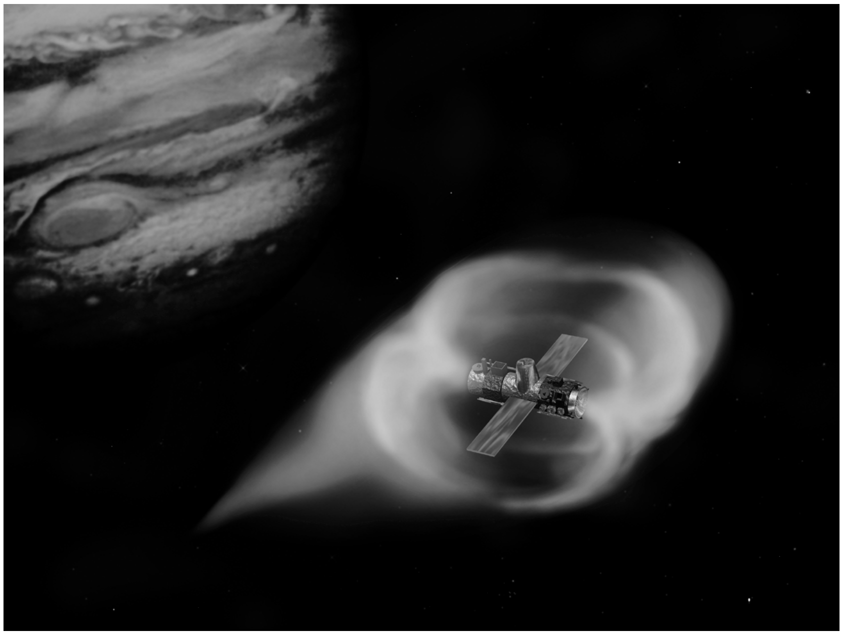
Temperature
-350 degrees Fahrenheit
(-212 degrees Celsius)

Atmosphere
83 percent hydrogen, 15 percent helium, 2 percent methane

Geology
Primarily rock and ice; helium/hydrogen core

Moons
21

Rings
11 faint rings



An artist's rendering of a plasma sail vehicle as it nears Jupiter

Space Sails

"Sailing" technologies offer additional means of sending vehicles to the outer planets without the need for heavy on-board fuel loads. Sunlight provides tremendous momentum that could push a solar sail about 100,000 miles (160,934 kilometers) per hour, making interplanetary travel four to six times faster than today's propulsion systems. Recent advances in strong, lightweight composite materials have helped intensify research in this area.

Another promising concept is the plasma sail, a huge magnetic bubble generated aboard a small interplanetary vehicle and pushed along by charged particles of the solar wind, which travel at speeds upward of 100,000 miles per hour. Plasma sail technologies could cut conventional trip times to the outer planets in half, benefiting research missions and perhaps one day serving as a means of resupplying vehicles parked in permanent orbit around other worlds.

In the next decade, NASA hopes to launch a space sail on an interstellar precursor mission to explore the edge of our solar system.

Aero-Assist Technologies

Aero-assist is a set of unique propulsion technologies intended to support missions to the most distant planets in the solar system. An aero-assist vehicle uses aerodynamic forces related to planetary atmospheric flight to control or alter its velocity.

A craft traveling to a distant destination, for example, may use an intervening planet's orbital energy to "slingshot" onward at a greater velocity. This technology is current used by most conventionally powered interplanetary survey crafts to help push them further and faster on their journey without the need for additional fuel.

To reduce flight times to the outer planets, future deep-space vehicles will fly at much greater speeds than modern craft, and therefore will require greater braking power once they reach their destination.

Aerobraking and aerocapture are technologies that use a planet's atmosphere to slow a craft to orbital speed without firing its rockets. Doing away with the extra fuel required for orbital entry would allow for lighter vehicle design, with more room devoted to science payloads.

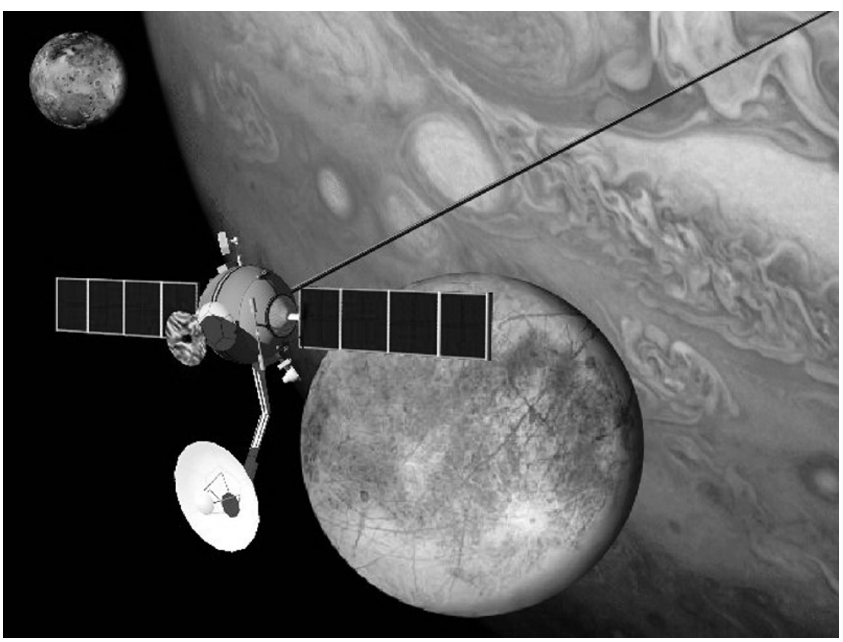
NASA researchers have proposed a demonstration in 2005 of an aerocapture system in Earth orbit—the first step toward making future interplanetary applications of aero-assist technologies a reality.

Electrodynamic Tethers

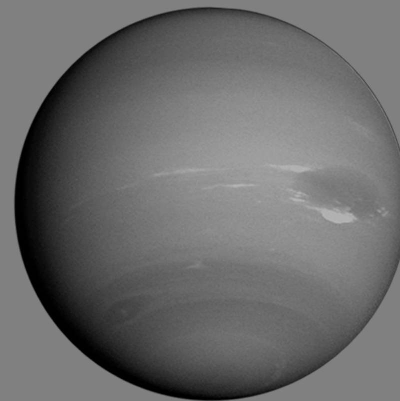
Tether propulsion—the generation of propulsive power by deploying an electrically charged wire in a magnetic field—is a cheap, efficient propulsion source which could turn orbiting, in-space tethers into "space tugboats"—replacing heavy, costly, traditional chemical propulsion and enhancing a variety of missions in space.

Given Jupiter's enormous magnetic field, NASA researchers are now investigating possible electrodynamic tether applications for future Jovian missions. The Galileo mission, launched to Jupiter in 1989, has provided scientists with a wealth of data about the gas giant, but the mission remains limited by Galileo's deplenished fuel load, which prohibits the craft from carrying out the complex orbital maneuvers needed for optimal, long-term study of the planet and its moons.

Development of an electrodynamic tether propulsion system would enable NASA to put a maneuverable, long-duration probe into Jupiter's orbit.



Artist's rendering of an electrodynamic tether at work in the Jovian system



Neptune

Distance from Earth
2.71 billion miles
(4.35 billion kilometers)

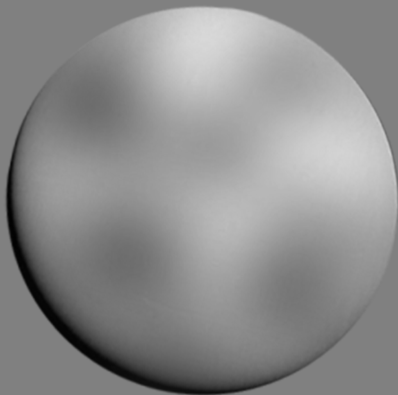
Temperature
-350 degrees Fahrenheit
(-212 degrees Celsius)

Atmosphere
Hydrogen, helium and methane levels similar to Uranus; fastest atmospheric winds in the solar system, exceeding 1,500 mph (2,414 kilometers per hour)

Geology
Gaseous outer surface; core of rock, ice, and liquid hydrogen

Moons
8

Rings
Four faint, dark rings



Pluto

Distance from Earth
3.58 billion miles (5.76 billion kilometers)

Temperature
-373 degrees Fahrenheit (-225 degrees Celsius)

Atmosphere
Indications of heavy nitrogen, with some carbon monoxide and methane; entire atmosphere may freeze solid except when closest to Sun

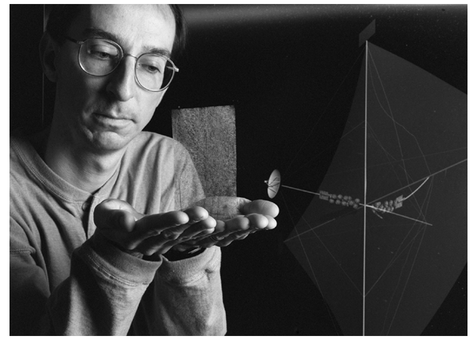
Geology
Studies suggest 70 percent rock, 30 percent water ice containing nitrogen, methane, ethane, and carbon monoxide

Moons
1 (Charon)

Note: For 20 years out of every 240, Pluto's orbit brings it closer to the Sun than Neptune. this phenomenon last occurred between February 1979 and February 1999. It will start again in 2219.

A Revolutionary Paradigm Shift

All these technologies represent NASA's efforts to decrease trip times and reduce the weight of propulsion systems required for outer planet missions, enabling us to routinely send robust, long-duration probes and survey craft to the outer solar system, and paving the way for eventual human exploration of our neighboring worlds.



Les Johnson, manager of the In-Space Propulsion investment area at NASA's Marshall Space Flight Center, displays a space sail fabric sample

The efforts of the In-Space Propulsion investment area to develop advanced propulsion systems will revolutionize NASA's interplanetary mission paradigm, allowing us to pick the right technology to match any proposed outer-planet mission, rather than developing missions that fit—and are limited by—the narrow parameters of existing technologies.

No longer can we focus on trying merely to get from Point A to Point B. Today, NASA seeks propulsion technologies enabling us to reach all points—quickly, safely and with a maximum return on investment—throughout our solar system and beyond.

About the In-Space Propulsion Investment Area

The coming generation of scientific exploration missions presents NASA with unique challenges. Chief among these: fast access throughout the solar system and the ability to rendezvous with, orbit and conduct in situ exploration of planets, satellites and small bodies.

It is the mission of the In-Space Propulsion investment area of NASA's Advanced Space Transportation Program to develop propulsion technologies that will benefit future NASA science missions by significantly reducing travel times required for transit to distant bodies.

For more information about NASA Space Transportation Systems, the Advanced Space Transportation Program and the In-Space Propulsion investment area, visit: http://www.spacetransportation.com

For More Information

Interviews on subjects of this fact sheet are available. Please contact Dave Drachlis of the Marshall Media Relations Department at (256) 544–0034.

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